GCSE: Physics (Electricity)

St Mary's University Twickenham London

Name:……

Have a look at https://www.youtube.com/watch?v=Ng5qzH39nyg to consider some difficulties when thinking about simple circuits.

Pre-Session Task

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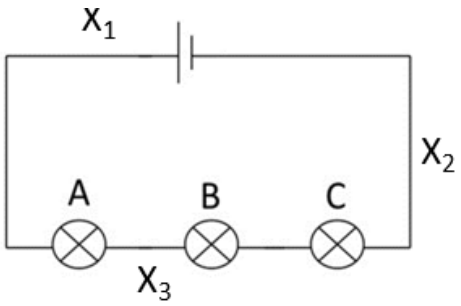
For each position X_1, X_2 and X_3 make a comment on current, resistance and voltage. Your comment may be specific to each position or may compare one position to another within the circuit.



	Comment
X_1	**Current:**
	Voltage:
	Resistance:
X_2	**Current:**
	Voltage:
	Resistance:
X_3	**Current:**
	Voltage:
	Resistance:

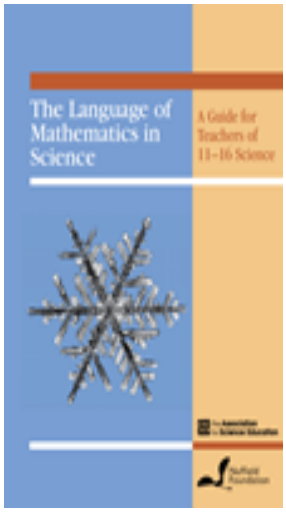
Task Check List

Activity	Page	Task details	Completed ✓
1	5	Explore the rods, balloons, paper and cloths to investigate this phenomenon. Check what affect a charged rod has on a small stream of water. Draw a diagram to explain what you believe is happening during this phenomenon.	
2	5	Explore the phet simulation https://phet.colorado.edu/sims/html/balloons-and-static-electricity/latest/balloons-and-static-electricity_all.html and practice using it to explain what is happening when you charge a balloon which then makes it attracted to the wall..	
3	6	a)Look at the national curriculum to consider what students might have been taught at primary school. b)How do you the energy stick works? What might the stick contain in terms of electrical components? How could this be used in the classroom? c) What misconceptions might primary students have? What is being elicited by the really big circuit?	
4a	8	Are you aware of the symbols on the right? Can you identify the items in a tray of electrical components?	
4b	8	Can you light a lamp with one wire and a cell (battery)?	
4c	8	Can you draw a simple circuit diagram to show a set up that includes a lamp, wires, an ammeter and a voltmeter?	
4d	8	Can you set up this circuit? Now do this again but with 2 lamps in parallel.	
4e	11	Using the circuits built on the previous page, investigate the current at various points within a series circuit. Does the current vary if the ammeter is placed either side of a component? Do the same but try with a parallel circuit. As you explore each circuit, consider the following questions as you work.	
5	15	GCSE Physics required practical activity: I-V Characteristics	
6	12	GCSE Physics required practical activity: Resistance (length of wire)	
7	14	AQA GCSE PHYSICS Higher Tier Paper 1H Specimen Question 2018	

Charge

Charge is a fundamental property of matter like mass. All matter can have charge.

This charge comes from the constituent parts of an atom, that is, the protons, neutrons and electrons. We say that a proton has a +1e (***elementary charge unit***) whereas an electron has a -1e charge. Charge may be either positive or negative. As the name suggests, neutrons are neutral and do not have a charge. If you consider the number of protons or electrons that maybe found in an atom and then consider the number of atoms in an 'object', you will soon realise that we would be dealing with very large numbers when considering an electrical circuit. We therefore use coulombs (**Unit = C**) to address this issue.



Additional reading 2.6 & 2.7 for hints as to how you may work with very large and very small numbers. (The Language of Mathematics in Science: A Guide for Teachers of 11–16 Science)Available at https://www.ase.org.uk/mathsinscience

A coulomb offers a macro scale for our elementary unit of charge. **1e = 1.6 10^{-19} coulombs**. The unit is C, but the unit name is coulombs, note the use of capitals and lower case.

When considering the charge on an atom you may count the number of protons and subtract the number of electrons to obtain the overall charge on the atom. To convert to coulombs you need to remember that 6 000 000 000 000 000 000 electrons or protons add up to 1 Coulomb. Later in this booklet we will consider electric current which is the flow of charge, but first we must consider static charge.

It is useful to consider static electricity as a foundation for circuit electricity. You should note that GCSE requires an appreciation that a charged object creates an electric field around itself that becomes weaker further away from the object.

Static electricity and fields

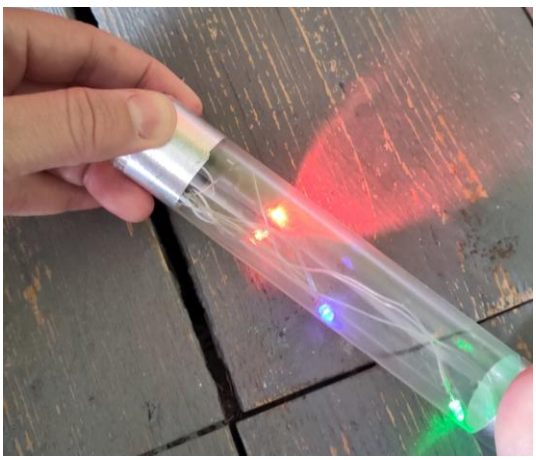
You may have rubbed a balloon with a cloth and found that it appears to be attracted to a wall or used it to make small pieces of paper ‘dance’. This phenomena is seen when insulating materials are rubbed against each other to make them electrically charged. We say that the negatively charged electrons are transferred from one of the materials to the other. We do not say that charge is created, it is not ‘new created charge’, but rather existing charge that has been transferred. This means that it one of the objects becomes negatively charged due to a transfer of electrons, the other object / material must now be considered as positively charged.

Task 1: Explore the rods, balloons, paper and cloths to investigate this phenomenon. Check what affect a charged rod has on a small stream of water. Draw a diagram to explain what you believe is happening during this phenomenon.

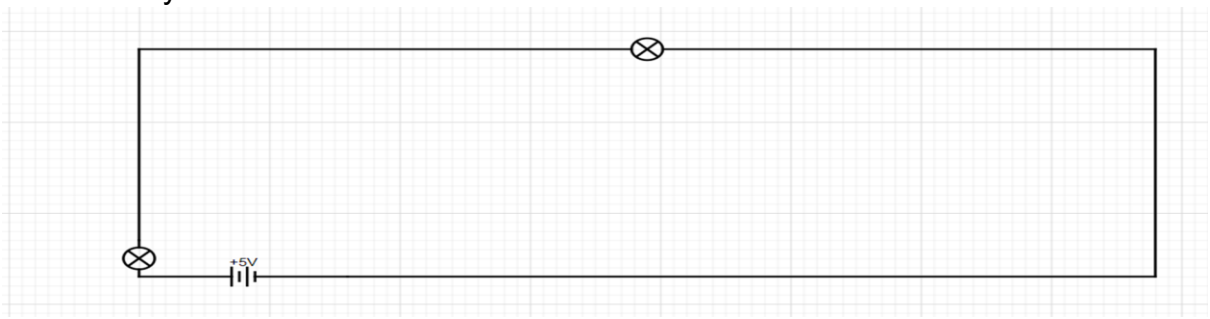
Task 2: Explore the phet simulation
https://phet.colorado.edu/sims/html/balloons-and-static-electricity/latest/balloons-and-static-electricity_all.html
and practice using it to explain what is happening when you charge a balloon which then makes it attracted to the wall.

Eliciting pupil ideas

Students will have come across ideas about electricity at primary school. It is important to acknowledge what they know and elicit any misconceptions.



An energy stick toy like the one above can be useful in capturing attention and asking students to apply their existing schema to new phenomena. It buzzes and flashes when both end are held.
Another example of a situation that can elicit what they know is to set up a really big circuit, with two bulbs and long wires between them (see below). Which bulb will come on first? Why?



Task 3: a) Look at the national curriculum to consider what students might have been taught at primary school.
b)How do you the energy stick works? What might the stick contain in terms of electrical components? How could this be used in the classroom?
c)What misconceptions might primary students have? What is being elicited by the really big circuit?

Models

Electricity can be a hard topic as we are asking students to observe what is happening on a macroscopic level (the bulbs are coming on), imagine what is happening on a microscopic level (the charges are moving round) and use symbols to represent different quantities.
Models can help students visualise what is happening on a microscopic level and so reduce some of the cognitive load. There are many different models used when teaching electricity. They are often good for specific purposes but can break down when applied too widely. Evaluating models is an important skill to teach your students.

The rope model: With the rope model, use a roop loop to represent the circuit. Stick pieces of tape at regular intervals onto the rope to represent the charges. You are the battery supplying the push and ask for a student to be the bulb. They have to let the rope run over the top of their open hands, which are likely to feel warm as a result. Students should be able to see the charges moving.

a) *Add another battery to the circuit. What do the students observe happening to the charges and therefore the current?*
b) *Add another bulb to the circuit. What do the students observe happening to the charges and therefore the current?*

Through careful questioning, you should be able to develop your students understanding as to what current is (amount of charge passing in a unit time) and what factors affect it (voltage and resistance).

Explore current in series and parallel circuits I

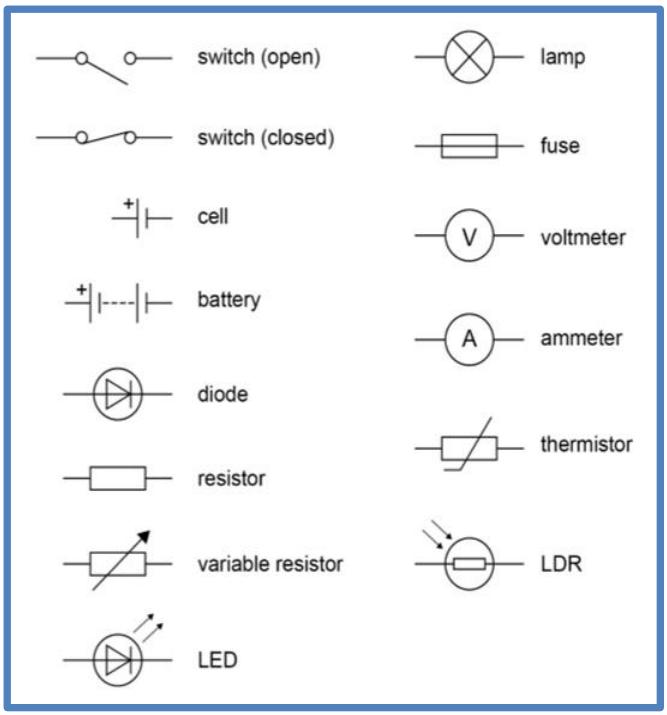
Before going further, please ensure you are familiar with the ideas on the next couple of pages.

Task 4a: Are you aware of the symbols on the right? Can you identify the items in a tray of electrical components?

Task 4b: Can you light a lamp with one wire and a cell (battery)?

Task 4c: Can you draw a simple circuit diagram to show a set up that includes a lamp, wires, an ammeter and a voltmeter?

Task 4d: Can you set up this circuit? Now do this again but with 2 lamps in parallel.



In series:

In parallel:

Explore current in series and parallel circuits II

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Task 4e: Using the circuits built on the previous page, investigate the current at various points within a series circuit. Does the current vary if the ammeter is placed either side of a component? Do the same, but try with a parallel circuit. As you explore each circuit, consider the following questions as you work.

- Why is a circuit a loop, or a number of loops?
- What causes the electricity to move?
- What would happen if there was not a 'load' (i.e. a lamp)? Don't remove all loads to check…… why not?
- Why are the ammeters and voltmeters connected in the way that they are?
- Cheaper low value Christmas tree lights are connected in series rather than parallel, why?
- Do you think resistance in a series circuit is higher or lower than in a parallel circuit, given the same components?
- Can you explain this difference?

Notes:

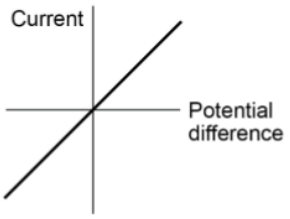
Current, voltage and resistance

Using the rope model, your students will have hopefully built up an understanding of

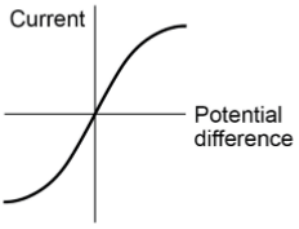
$$\text{current} = \frac{\text{voltage}}{\text{resistance}}$$

As the voltage increases, the current increases
As the resistance increases, the current decreases
This equation help show the relationship between current voltage and resistance (when temperature is constant) and is known as Ohm's Law.

For an ohmic conductor, where temperature is constant current is directly proportional to potential difference. The resistance remains constant as the current changes.



However, in a lamp where the temperature changes, the resistance will alter. As the lamp heats up the resistance increases and therefore the current is lower than may be expected in an ohmic conductor. Note the 'flattening' curve at the top of the graph. The increase in p.d. is not matched by an increase in current.



At GCSE students will be required to **investigate the I-V characteristics of a filament lamp, a diode and a resistor at constant temperature** as well as **investigating the factors that affect the resistance of a wire**.

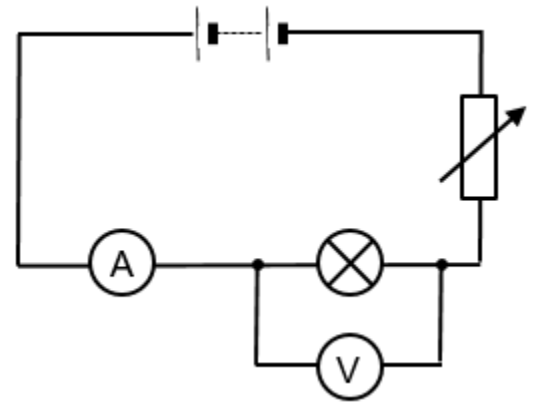
Task 5: GCSE Physics required practical activity: I-V Characteristics

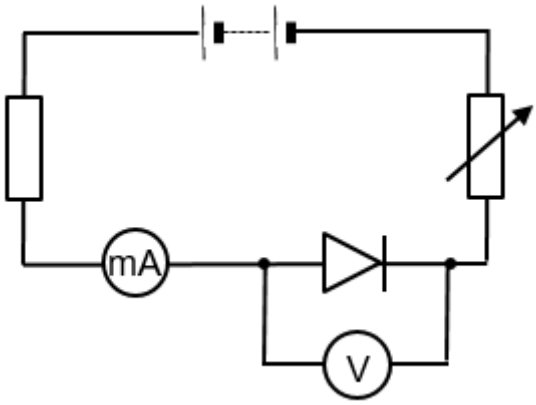
Using circuits set up as those on the right, you can investigate I-V characteristics of variety of circuit elements including a filament lamp, a diode and a resistor at constant temperature.

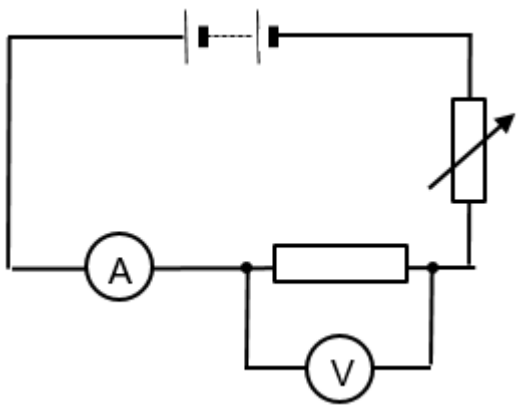
Use the following to plot a graph of current against voltage.

- ammeter / milli-ammeter (for diode exp.),
- voltmeter
- power pack
- lamps
- connecting leads
- Diode
- 'protective' resistor (e.g. 10 Ω)

Consider the following:
- Safety – components may get hot!
- Diodes are affected by direction of current.

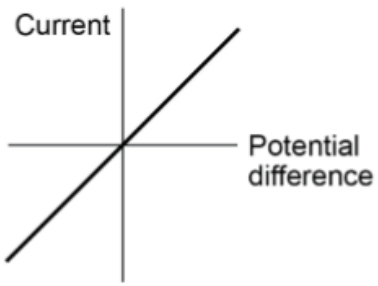






Do not assume the resistance is the slope of the graph. In this instance we would be calculating 'rise over run' - giving I / V.

Remember, it should be $R = \frac{V}{I}$ so a simple gradient does not work here.



Task 6: GCSE Physics required practical activity: Resistance (length of wire)

Set up an investigation to explore how resistance changes with the length of wire used. Use the following apparatus for your investigation and ensure you have considered safety issues such as over heating.

- power supply
- Constantan wire (copper-nickel alloy)
- metre ruler
- ammeter
- voltmeter
- crocodile clips
- connecting leads

You should consider how the circuit will appear and how many readings you will need to take. Draw a simple circuit diagram and use the draft a table below.

Hint: The investigation will require you to take multiple readings using a set up similar to the diagram below. **This investigation is developed at A level by the determination of resistivity of a wire using a micrometer, ammeter and voltmeter**.

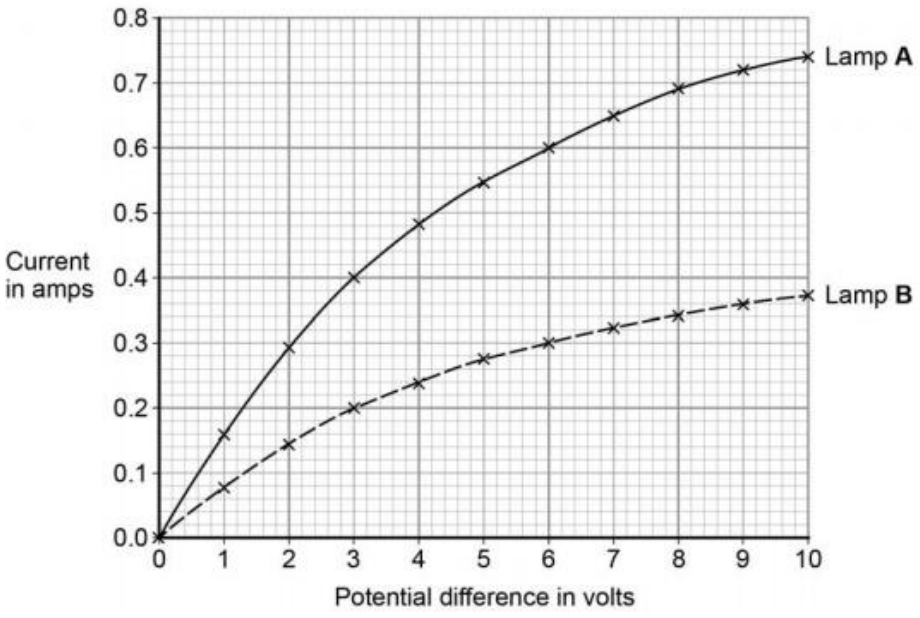
Move the croc clip to alter the length of wire!

Circuit diagram:

0 8 A student investigated how current varies with potential difference for two different lamps.

Her results are shown in **Figure 10**.

Figure 10



0 8 . 1 Complete the circuit diagram for the circuit that the student could have used to obtain the results shown in **Figure 10**.

[3 marks]

0 8 . 2 Which lamp will be brighter at any potential difference?

Explain your answer.

Use **Figure 10** to aid your explanation

[2 marks]

0 8 . 3 Lamp **B** has the higher resistance at any potential difference.

Explain how **Figure 10** shows this.

[2 marks]

0 8 . 4 Both lamps behave like ohmic conductors through a range of values of potential difference.

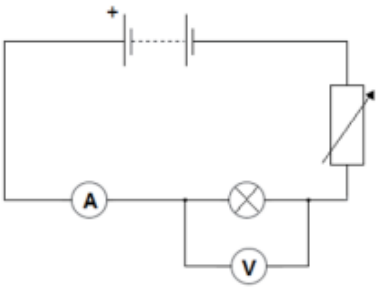
Use **Figure 10** to determine the range for these lamps.

Explain your answer.

[3 marks]

AQA GCSE PHYSICS
Higher Tier Paper 1H Specimen 2018

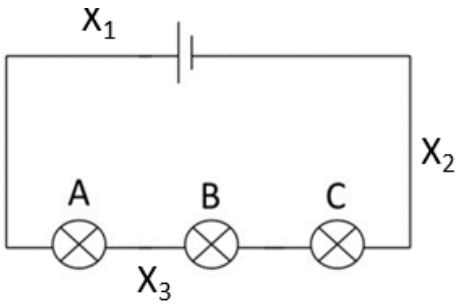
Question 8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1		battery in series with bulb and ammeter voltmeter in parallel with bulb variable resistor **or** variable power pack **or** potentiometer	1 1 1	AO1/2 4.2.1.1/3 WS2.2
08.2	A is brighter because it has a higher current (than lamp B at any p.d.) (therefore A has a) higher power output (than bulb B)	 accept higher energy output per second	1 1	AO3/1a AO1/1 4.2.4.1/3
08.3	lower current (than lamp A) for the same potential difference lower gradient (than lamp A)	accept answer in terms of R = V/I	1 1	AO1/1 AO2/2 4.2.1.3/4
08.4	0 – 2 Volts (for an ohmic conductor) current is directly proportional to potential difference (so) resistance is constant	allow a range from 0 V up to any value between 1 and 2 V. allow lines (of best fit) are straight and pass through the origin	1 1 1	AO3/2b 4.2.1.3/4
Total			**10**	

It should be noted that this new question clearly emphasises the need to use recall of knowledge, mathematical skills to answer the questions and experience of the practical.

Post Session Task

For each position X_1, X_2 and X_3 make a comment on current, resistance and voltage. Your comment may be specific to each position or may compare one position to another within the circuit.



	Comment
X_1	**Current:**
	Voltage:
	Resistance:
X_2	**Current:**
	Voltage:
	Resistance:
X_3	**Current:**
	Voltage:
	Resistance: